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STUDY OF MAGNETIC MOTIONS IN THE SOLAR PHOTOSPHERE AND THEIR IMPLICATIONS FOR HEATING THE SOLAR ATMOSPHERE

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Study of Magnetic Structure in the Solar Photosphere and Chromosphere

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Observations of the CO rotation-vibration lines at 4.6 μm

We continued our program of CO observations with the McMath-Pierce facility at Kitt Peak National Solar Observatory. Uitenbroek was able to observe for 6 days with especially good seeing in the mornings of the last three days. The data will be reduced shortly. Our hope is that we can confirm an earlier observation with good seeing condition which showed that the granulation plays an important role in the shaping of the CO spectrum at small spatial scales. In particular the coolest regions seemed to be associated with the centers of strong granules, presumably due to the strong adiabatic cooling that occurs when granules expand horizontally.

Multi-dimensional modeling of CO line formation

Uitenbroek has developed a two- and three dimensional radiative transfer code that now includes chemical equilibrium calculations. This code allows us to compute a CO spectrum from for instance a snapshot of a solar granulation simulation (e.g. Stein & Nordlund 1989, Apj 342, L95) and compare these theoretical spectra with our spatially resolved CO spectroscopy. Figure 1 shows the result of such a calculation in a two-dimensional cut (in the $x - z$ plane) through a 3-D granulation snapshot. One thing to note is that the CO line core intensities show a contrast reversal with respect to the

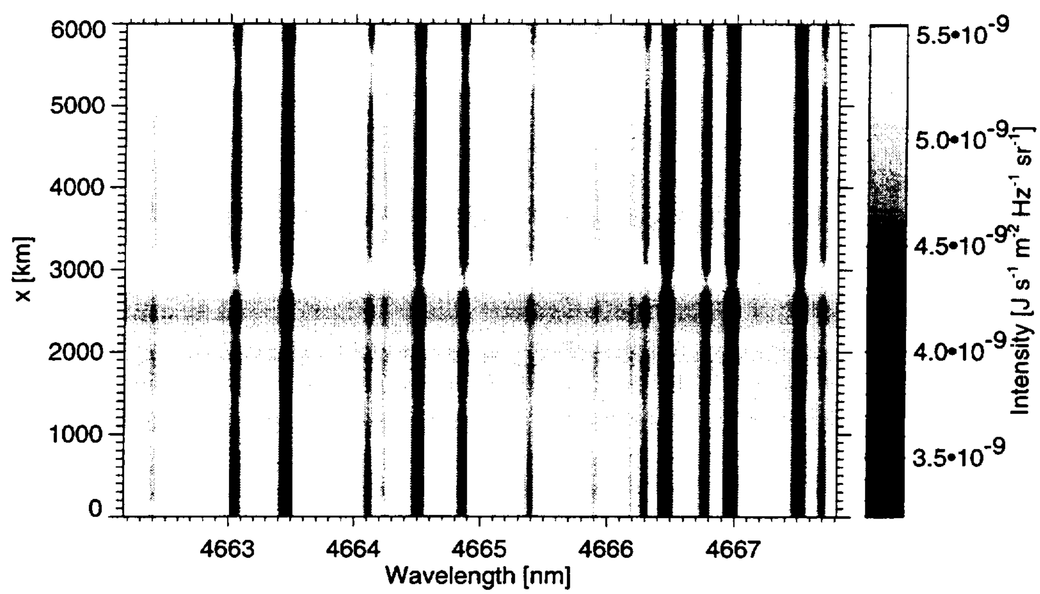

Figure 1: Theoretical spectrum of CO lines in a two-dimensional cut through a granulation simulation.

intensities in the adjacent continuum. This is more borne out more clearly in Figure 2, which shows the spectrum for two specific locations (corresponding to $x = 0$ km and $x = 5300$ km in Figure 1). The solid curve in this figure represents the intensity, at disk center, from the center of a bright (as judged from the continuum at 4.6 μm) granule. The dashed curve represents the intensity from a dark intergranular lane. The theoretical calculation clearly suggests that the darkest areas in the CO line

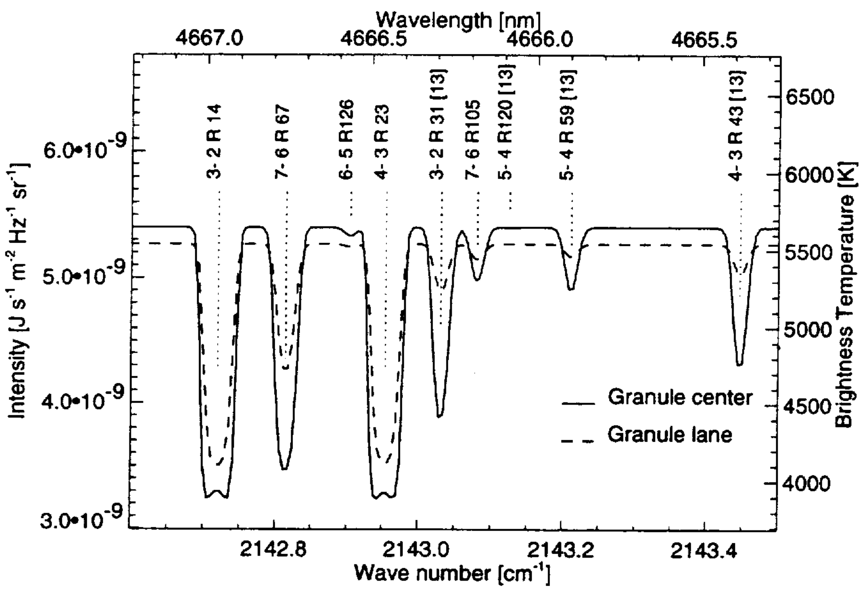

Figure 2: Theoretical spectra corresponding to bright granule (solid curve) and dark intergranular lane (dashed curve). Brightness temperatures are indicated in the righthand scale.

cores are the centers of strong granules, in agreement with our best spatially resolved observations which barely resolve the granulation. Hopefully our most recent observations discussed above will provide even more evidence for this effect.

Multi-dimensional radiative transfer in magnetic fluxtubes

Van Ballegooijen and Uitenbroek have started calculations of two-dimensional fluxtube models that account consistently for hydrogen ionization in the calculation of the electron density. To this end we solve radiative transfer for hydrogen (bound-bound and bound-free transitions) in the two-dimensional models, including the effect of partial frequency redistribution (PRD) in the Lyman α and β lines. We iterate between the radiative transfer solution and the solution of magnetostatic equilibrium to get internally consistent values of total pressure (magnetic plus gas), density, electron density and temperature. We prescribe the pressure, density and temperature on the axis and in the ambient medium with semi-empirical models by Avrett. The iterative procedure converges in 7 iterations to relative changes in electron density of less than 0.1%. Figure 3 shows the electron distribution and the run of 15 selected field lines in one of the models.

From our internally consistent models we will calculate emergent spectra and the way these vary with location of some well-known spectral diagnostics and compare our results with observed line profiles. We can readily compare theoretical CO profiles from out models with our spatially resolved

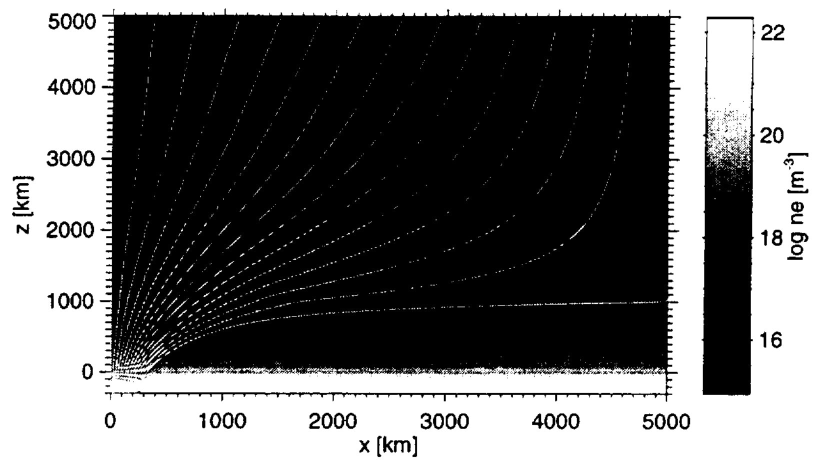

Figure 3: Logarithm of the electron density and the run of 15 selected magnetic field lines in one of the converged magnetostatic models.

CO observations. Also we can compare with spatially resolved Ca II (ground based) and Mg II (we have observations done with the UVSP/SMM instrument), and Lyman α observations that should be available from SUMER/SOHO.